We have shown that the colour was in proportion to the amount of copper present, and that the colourless leucocytes contained only traces of that metal. The deposition of the copper in this large quantity appears to us to represent a degenerative reaction; it was accompanied by a most striking increase of leucocytes, which tended to distend the vessels and to collect in clumps, phenomena which are abnormal in our experience in the oyster. The presence of the copper in the leucocytes in these cases might be compared to that of the iron which is met with in some of the leucocytes in cases of old hæmorrhages, pernicious anæmia, or in other cases where iron is set free. We are not prepared to state whether copper in the food can bring about the condition, but certainly we have abundant evidence to show that it can occur where no copper mines or other evident sources of copper are present.

We are inclined to suggest that the increase of copper may be due to a disturbed metabolism, whereby the normal copper of the hæmocyanin, which is probably passing through the body in minute amounts, ceases to be removed, and so becomes stored up in certain cells.

Our results also show that hæmatoxylin is a most valuable reagent, not only as Macallum has shown in the case of iron, but also in that of copper, and that care must be taken to distinguish between the two reactions; and this must be especially the case in those invertebrata where copper plays an important *rôle* in the physiology of the blood.

"Stress and other Effects produced in Resin and in a Viscid Compound of Resin and Oil by Electrification." By J. W. Swan, F.R.S.

Received May 17,—Read June 17, 1897.

(Plates 1—4.)

While making an experiment with the object of finding the degree of resistance to puncture offered by paper coated with a soft compound of resin and oil, when placed between the secondary terminals of an induction coil, the tension being regulated by a spark-gap in a parallel branch of the circuit, observed that on the passage of a spark at the spark-gap, while no spark passed between the paper-separated terminals, a sudden roughening or puckering of the previously smooth surface of the coating took place.

A number of experiments were made with the object of ascertaining the nature of the action which produced this effect, and these led to further experiments and to results which, though closely related to well-known phenomena, possess features of novelty and interest.

It was found that clear Bordeaux resin in a viscid state (viscidity being brought about either by heat or by the addition of resin oil) is responsive to the mechanical stress consequent on electrification by non-luminous discharges; and if it is so acted upon while in the solid state, and afterwards superficially softened by heat, there results a new kind of electric discharge figure, analogous to the dust figures of Lichtenberg and Lord Armstrong, but showing some remarkable peculiarities which throw additional light on the mechanism of air-conveyed electrical discharges, and on the location and nature of the stresses imparted to the dielectric. I ascertained that a smooth surface of resin is retentive of an electric charge to an extraordinary degree, that after more than two months the lines of an electric discharge figure, as developed by heat, and as further developed by the accidental attraction of atmospheric dust to the electrified parts of the surface, were still attractive of dust in a discriminative manner, no change being observable upon re-dusting either in the arrangement or definition of the lines of electrification as originally developed.

The apparatus employed consisted of an induction coil or a Wimshurst machine, and a supporting stand, the rod of which carried two clips and a stage, the supporting part of the stage being made of strips of thick plate-glass, and the rest of wood. The clips held conducting wires, which passed through bent glass tubes, and went to the secondary terminals of the induction coil, or to the conductors of the Wimshurst machine; the discharging arms in either case constituted an adjustable spark-gap in parallel with the wires ending above and below the stage. The stage terminals were balls, discs, or points; the pairs employed in different experiments varied in size and form, and the pair used together were sometimes dissimilar. The resin was the colour of amber; in some of the experiments it was used in a solid state, but fused to the form required for experiment; in other experiments it was softened to semi-liquidity by the addition of 20 per cent. or more of resin oil, the mixture being made by fusion together of the resin and oil. The compound with 20 per cent. of oil has the consistency of treacle at a temperature of 20° C.; at 12° C. it is nearly solid, yet plastic enough to yield to the mechanical stress-action generated by the projection upon its surface of an electric discharge of the kind employed in the experiments. At the higher temperature the viscid liquid is well suited for showing the great disturbance produced by repeated discharges, and when at the lower temperature it is convenient for observing the more persistent forms of the figures produced on the surface by single discharges under various conditions. When it was required that the stress figures should be permanent, resin either alone or with not more than 2 or 3 per cent. of resin oil was used.

The dielectric was either contained in glass basins or spread as a coating of 0·5 to 1 mm. thick upon glass or mica plates, and in a few cases on copper plates. Also plates consisting wholly of resin were in some instances used.

The effect of a spark passing at the spark-gap, when one of the stage terminals is suspended over, and at a certain distance from the viscid resin and oil mixture contained in a basin, the other being in contact with a metallic disc under it, is to produce an evanescent figure on the surface.

The character of the figure depends on:—

1. Whether the terminal over the dielectric surface is positive or negative.
2. The form and size of the + and − terminals.
3. The distance of the upper terminal from the surface of the dielectric.
4. The potential and character of the spark at the spark-gap.

Typical Effects.—The most regular and characteristic stress figures are obtained when the spark-gap is adjusted so as to prevent the passage of a spark or visible brush through or over the dielectric, but allow a non-luminous discharge to take place of only slightly less strength than would be necessary to produce a brush discharge visible in the dark. A typical effect is obtained when the spark-gap is 25 mm., and the positive branch from it terminates in a brass ball of 8 mm. diameter hanging centrally over, and 4 mm. from the surface of, the dielectric (80 per cent. resin and 20 per cent. resin oil at 20° C.) contained in a glass basin 150 mm. diameter and 15 mm. deep, the negative wire being brought to a disc of metal 100 mm. diameter under the basin, or to a disc of tinfoil attached to the underside. On breaking the primary circuit by means of a mercury break with a trigger action (the spark-gap having been momentarily short-circuited while the primary circuit was closed), and the consequent passing of a single spark at the spark-gap—no visible discharge occurring between the ball and the dielectric—there suddenly breaks out on the surface of the viscous liquid a star-shaped figure formed of deeply furrowed, closely clustered, outward-branching rays, extending from a circular frill near the centre to the margin of the liquid. The figure gradually dies down, and on the surface becoming smooth it can, with slight variations, be reproduced again and again by repeated breaks of the primary circuit.

If the commutator is reversed (the spark-gap being momentarily closed while the primary circuit is re-made), then on breaking the primary circuit as before, a figure characteristic of the negative convective discharge is produced. This figure is much smaller and weaker than the positive one; most frequently it consists of a

circular, or nearly circular, band or ring, more or less indented in outline, enclosing leaf-like rays which tend towards the centre. These are relatively broader and less branching than the rays of the positive figure, and they are characterised by having their outlines in relief, while the rays of the positive figure are sunk below the plane of the surface. When the electrification is strong, the ring enclosing the rays stands up as a frill in considerable relief.

Effect of the Form of the Terminal.—The character, both of the positive and negative figures, is greatly affected by the form of the discharging electrodes. When the upper terminal is a metallic disc of 25 mm. diameter, hanging in a plane parallel to, and 2 mm. above, the dielectric surface, and the other terminal is a 50-mm. metallic disc supporting the basin, complicated, but nearly symmetrical, figures of great beauty are obtained. A metal point opposed to a metal point, or a metal point above and a small metal ball below, give smaller figures of more elementary forms, having the general characteristics of the larger figures.

Balls and points as terminals tend to produce circular figures in which the rays converge to, or diverge from, one centre. This rule applies with fewer exceptions to the + figure. The negative figure, even when produced by a discharge from a brass ball, is frequently a combination of sectors, whose centres are not far apart, and are concentric with the centre of the group. The effect of this is to produce a figure of nearly circular outline broken by more or less regular indentations.

If the ordinary vibrating contact-breaker be employed instead of the trigger-break used in the foregoing experiments, the rest of the arrangement remaining as described, larger and more complicated effects are obtained. When the ball above the liquid is positive, the resin and oil being at a temperature of 20° C., on breaking the primary circuit the first effect of the make-and-break is the production of the characteristic star with arborescent rays; the repetitions of the impact which instantly follow indent the lines of the figure more and more deeply, and result in the effacement of the more regular figure, and the development of a large and turbulent movement of the liquid, tending to its division into two masses: a central mound with a flat or concave top and a concentric ring. At first the two masses are joined by radial ridges, but these gradually thin, and (if the discharges at the spark-gap are continued) eventually break down and leave the central mound and the embracing ring completely separated. During the progress of the action the ring portion is driven outwards, and when the limit of outward movement is reached, there is a subsidence of the more violent agitation, the outer ring becomes somewhat smoother and flows inwards; this is followed by a recurrence of the repellent action, and a repetition of the last

phase of the phenomena described. Figs. 1 and 2 represent in profile the appearance at the middle and final stage of the action.

Fig. 1.—*Positive.* Nearly Maximum Effect.

Fig. 2.—*Positive.* Maximum Effect.

If a metal ring (of 90 mm. diameter) is substituted for the disc, similar but more sharply defined effects are obtained. When the arrangement described is varied by making the ball over the basin negative, instead of positive, on breaking the primary circuit there is less displacement of the viscid material consequent on repeated interruptions of the circuit. To obtain a characteristic effect of repeated negative discharges, the spark-gap should be widened to 50 mm., and to prevent sparking over the edge of the basin, it should be at least 150 mm. diameter. There is then formed, immediately under the ball, a concavity the counterpart in size and curvature of the ball, and outside this there is the general figure, somewhat faint and tremulous, which seems to be a complication of the positive and negative figures, the characteristic positive figure encircling the more distinctly negative portion. Fig. 3 is a profile view of the negative displacement. The extent of the effects described is considerably modified by the degree of viscosity of the liquid, and this can be controlled by temperature.

Fig. 3.—*Negative.* Maximum Effect.

Corresponding but modified phenomena are produced by means of the Wimshurst induction machine. When, for example, an 8 mm. metal ball connected to the + arm of the discharger hangs 15 mm. from the surface of the resin and oil mixture of the consistency of treacle contained in a large basin, and the − arm of the discharger is connected to a metal disc of 100 mm. diameter under the basin, the discharger balls being 75 mm. apart, the result of continuously working the machine is the production of a turbulent motion, attended by the

formation of vortices into which the upper stratum of the liquid pours downward, carrying adherent air with it, while an equal and opposite movement takes place from below, producing worm-like eruptions of spirally twisting or wriggling jets of liquid at the surface. If the margin of the dish beyond the surface of the liquid is thinly smeared with the viscid liquid, the film breaks up into dew-like beads.

With a metal ball of 150 mm. diameter, 6 mm. above the surface of the liquid and a proportionately larger disc basin and depth of liquid, acted upon by a machine of moderate power, the spark-gap being adjusted so as to prevent sparks passing from the ball to the liquid, and the tension such as to keep up a strength of electrification of the surface only slightly less than that which would cause disruptive discharges to pass, a column of liquid rises and connects the overhanging ball and the surface of the liquid in a manner strongly suggestive of water-spout phenomena. The ascent of the column of liquid is followed by the descent of numerous thin surrounding streams, and these keep up a regular system of upward and downward circulation.

Fixation of Characteristic Effects.—In order to fix the various forms produced in the viscous mixture of oil and resin, an experiment was made with nearly pure resin, rendered plastic by heat, and cooled to solidity while under the action of electric discharges. It was found to be difficult to carry this out in a satisfactory manner, but it suggested a reversal of the procedure, viz., the electrification of a surface of resin in a solid state, and the subsequent development of the stress effect by rendering the surface superficially plastic by heat. This mode of operation resulted in the production of permanent relief and intaglio figures, corresponding to Lichtenberg's dust figures, to Brown's photographs,* and to the dust figures and photographs more recently described by Lord Armstrong.†

The preparation of the resin surface for the production of the permanent figures requires care. The method I employed is as follows:—A thin glass basin was filled with a mixture of resin and 5 per cent. resin oil, the oil being added to lessen the tendency of the resin to fracture on sudden change of temperature. The resin, melted in a metal pan, was poured through a filter of muslin into the basin, while embedded in small shot and raised to the fusion temperature of resin. On slowly cooling, the basin being meanwhile covered with a plate of glass or an inverted basin, the resin solidifies with a smooth bright surface. The resin-filled basin was partly covered, on the bottom, by a disc of tinfoil, and was placed centrally

* 'Phil. Mag.,' vol. 26, p. 502.

† 'Electric Movements in Air and Water, with Theoretical Inferences,' by Lord Armstrong, C.B., F.R.S. London: Smith, Elder and Co., 1897.

on a metal disc in contact with one of the wires from the spark-gap of the induction coil, the other wire, ending in a point, disc, or ball, overhanging the surface at the distance of a few millimetres as in the experiments with the viscous material described. On the production of a single spark at the spark-gap by means of the trigger-action mercury contact-breaker, a charge is conveyed to the resin. The peculiar distribution of this charge, and that it is attended by strong and enduring mechanical stress, can be made manifest either immediately, or many hours afterwards, by slightly warming the surface of the resin. The result is a deeply impressed figure, having the same character as the figure produced on the viscid dielectric. These solid figures, if carefully developed, show much fine detail; unfortunately, this is not capable of complete illustration by photographs. Difference of depth in the grooves is not fully indicated, neither is there represented adequately a peculiar burring of the margin of the grooves, especially in the negative figures, their edges rising slightly above the plane surface, as though the resin had been finely carved.

Persistency of the Stresses.—The persistency and fixity of the electrification of the resin surface, determining the form and character of the eventual figure, are very remarkable. If the development of the effect of the charge is delayed for twenty-four hours there is but little difference in the result from that which follows immediate development.

Dust Figures and Stress Figures combined.—It was found that the heat-developed figures attracted dust from the atmosphere, and thus formed, accidentally, a combination of a stress figure and a dust figure. The attracted dust gave clear indications of electrification beyond the limit of the stress figure, and brought out features of detail which helped to explain the nature of the electrification. Analysis of the character of the figures in this respect is still further helped by combining a modification of the dust process of Lichtenberg with the stress effect described in this paper. The modification referred to consists in allowing the dust—the mixture of red lead and sulphur proposed by Lichtenberg—to be *drawn up* to the electrified surface from a cloud of dust. This assists in the selective appropriation of the two substances, giving a redder colour on the negatively electrified portions of the figure, and a yellower colour on the positive portions; and showing what the stress figure alone does not show with equal clearness, how inseparable are the + and − actions. The best effect is obtained by applying the dust process before development by heat. Figs. 4 and 5 (Plate 1) represent characteristic forms obtained by positive and negative discharges with a metal ball electrode above the surface and a metal disc below, fig. 4 being + and fig. 5 −. Figs 6 and 7 are corresponding figures obtained with discs above and below, fig. 6 being + and fig. 7 −.

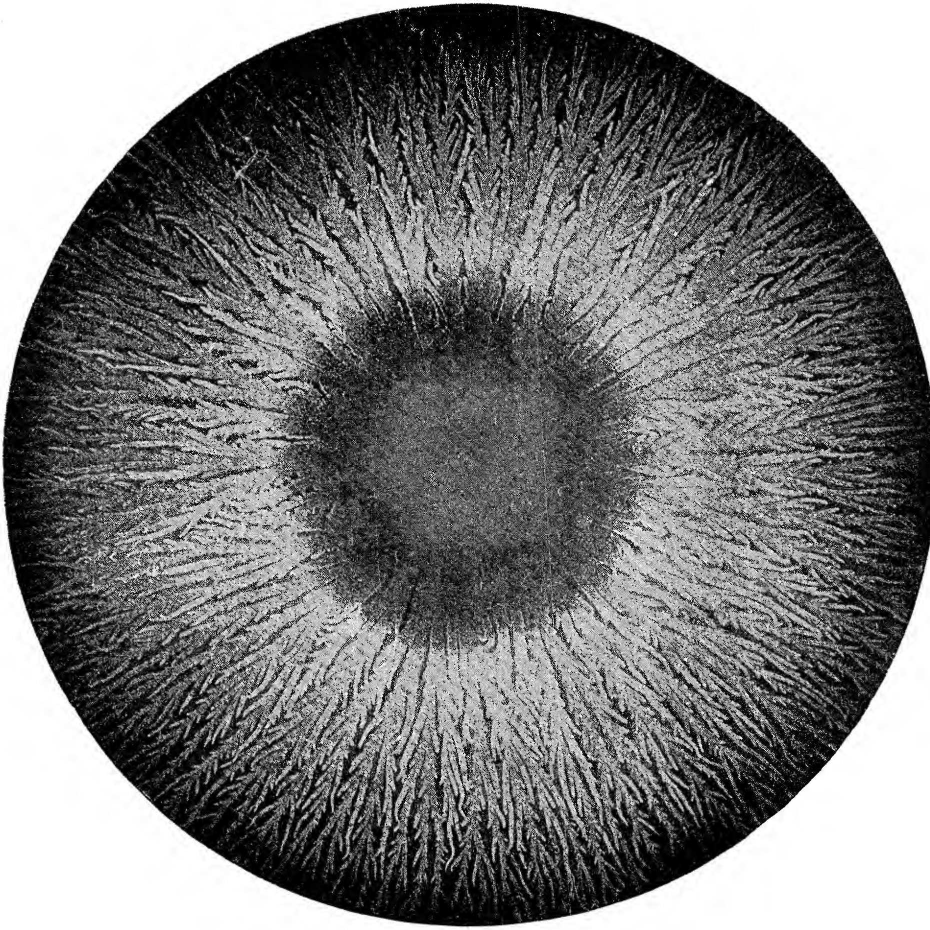


Fig. 4.

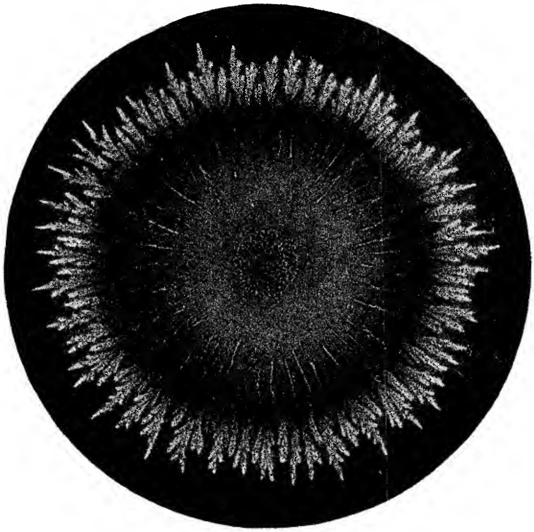
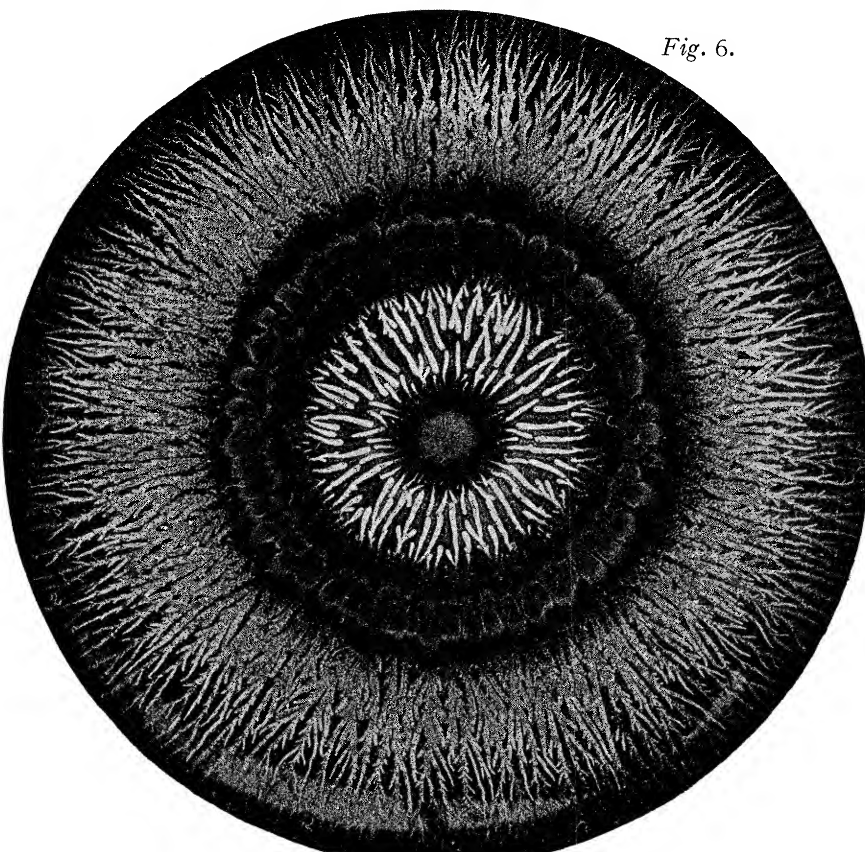


Fig. 5.

Fig. 6.



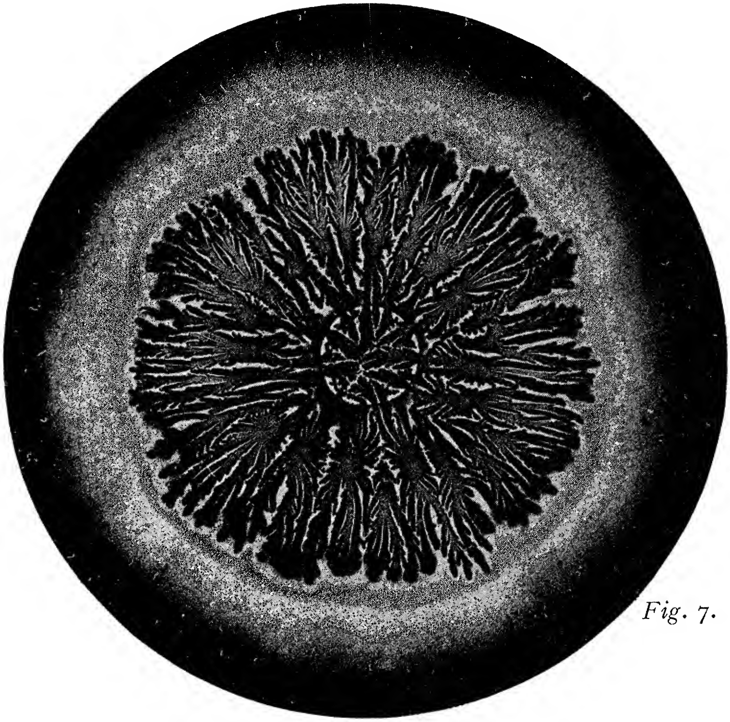


Fig. 7.

Fig. 8.

Fig. 9.

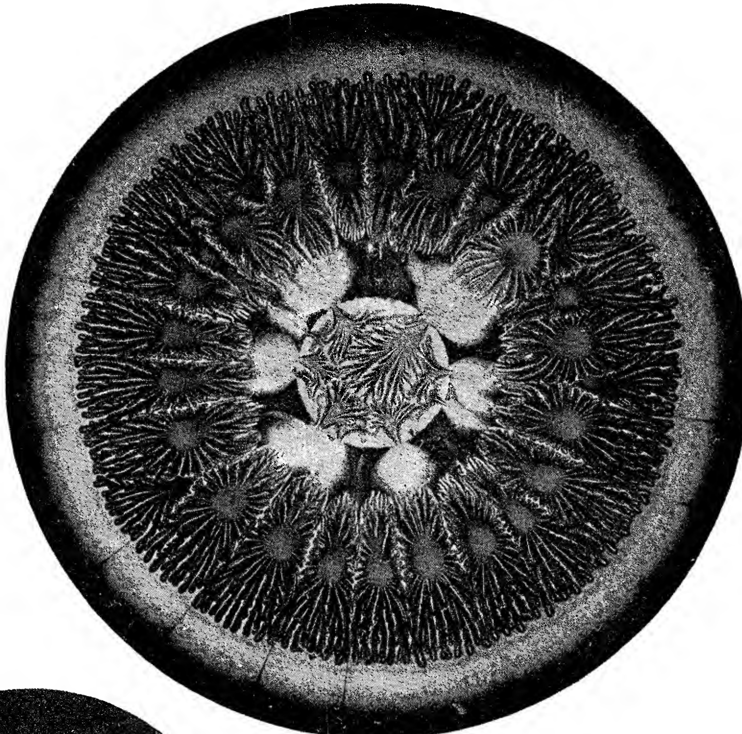
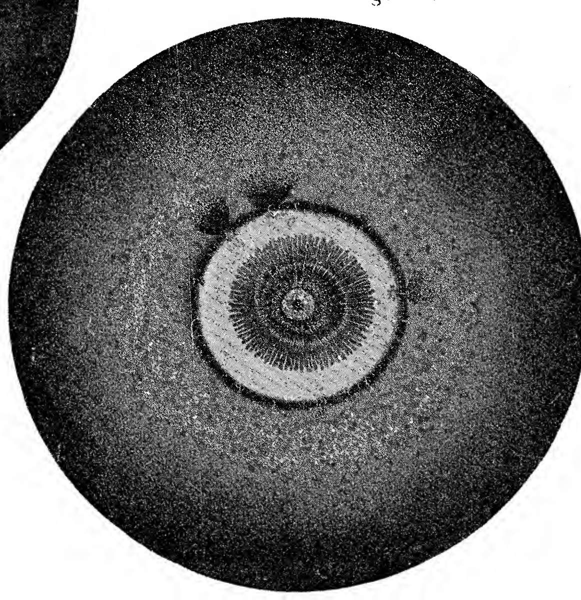


Fig 10.

Fig. 11.



Figs. 8 and 9 are additional examples of negative discharge figures with larger disc electrodes.

An excellent dust figure, in which the result of + electrification is strongly developed, is obtained by suspending, face downwards, an electrified resin surface in a very thin fume-cloud produced by burning magnesium ribbon. The fume should be enclosed in a box, or under a glass shade, and an hour should elapse for the coarser particles to subside before the introduction of the electrified surface. Sulphur in a state of sublimation can also be used in the same way with good effect, especially for very small areas of electrification, where microscopically fine development is required. On the whole, however, I have found nothing better than red lead and sulphur ground separately to very fine powder, and used very dry in a dusting box, the electrified surface always being downward when exposed to it.

With the object of finding the degree and kind of interaction between the positive and negative electrification produced on opposite sides of a solid dielectric, interposed in the path of a single discharge, the following experiment was made:—A thin plate of glass was coated on both sides by dipping in melted resin, this was electrified by bringing the secondary terminals of the induction coil, arranged as in the experiments already described, to opposite sides of the plate. The terminals were brass balls 8 mm. diameter, placed in a vertical line, the + above, the − below the plate in a horizontal position; the + ball was 1 mm. distant from the upper surface of the plate, and the − ball was in contact with the under surface. Under these conditions when an 8-mm. spark passed at the spark-gap, reciprocal figures of a very interesting character were produced, a + figure on the upper surface and a − figure on the under surface.

To enable photographs to be taken of these figures without interference, the experiment was repeated with the variation that a plate of ruby glass coated with resin on both sides was used instead of clear glass. The latent figure was first developed by means of the red lead and sulphur cloud, and afterwards the stress effect was brought out by heat. Fig. 10 shows the form of the figure on the + side, and fig. 11 that on the − side. When these double figures are viewed by transmitted light, it is seen that the interior − rays on one side, coincide with the inner ends of the outward streaming + rays on the opposite side.

That the depth of penetration of the charge which produces these figures is very small is shown by the almost complete discharge effected by washing the electrified surface with water.

The experiments seem to show that when an electric discharge takes place through air, its propagation is attended by a structural arrangement of the air brought under the influence of the discharge,

and that when a dielectric like resin is interposed in its path, some of the characteristics of the form into which the electrified air has been thrown are transferred to the resin surface as an electric charge, generating the stresses and other inductive effects which result in the dust and stress figures.

Experiments corresponding to those described made in an atmosphere of carbonic acid gas at normal atmospheric pressure, and in air at pressures lower than the normal, show that the character of the figure imprinted on a dielectric in receiving an electric charge through a gaseous medium is largely dependent on the density of the atmosphere conveying the charge; greater density tending to concentration of the figure and attenuation to diffuseness. With an air pressure supporting 85 mm. of mercury, the other conditions being such as would have given at normal pressure a characteristic + star figure, there was diffuse electrification of the resin surface, but there were no rays.

"On the Brains of two Sub-Fossil Malagasy Lemuroids." By C. I. Forsyth Major. Communicated by Henry Woodward, LL.D., F.R.S., V.P.G.S. Received April 6,—Read June 3, 1897.

(Plate 5.)

The casts here described and figured have been moulded from the brain-cavities of the skulls of two sub-fossil Lemuroids from Madagascar, the descriptions of which I have already published. For comparison with the brains of living Lemuroids the figures published by P. Gervais* are the best adapted for the *present* purpose, since they, too, are drawn from moulds of the brain cavity, and give on one plate a good general idea of the variations of the Lemur brain.

1. *Globilemur Flacourti*, Maj.

The larger of the two casts was taken from the skull briefly described by me at the meeting of the Zoological Society of London, June 20, 1893.†

In its general contours, as viewed from above (fig. 1), the brain of this form, for which I now propose the name of *Globilemur Flacourti* (*g. n. et sp. n.*), approaches most to that of the smallest members of the family (Lemuridæ), viz., *Microcebus*,‡ both being remarkably broad

* Paul Gervais, "Mémoire sur les formes cérébrales propres à l'ordre des Lémurs, accompagné de remarques sur la classification de ces animaux," 'Journal de Zoologie,' vol. 1, 1872, pp. 5—27, Pl. 2.

† 'Zool. Soc. Proc.,' 1893, pp. 532—535.

‡ P. Gervais, *loc. cit.*, fig. 7, Pl. 2.

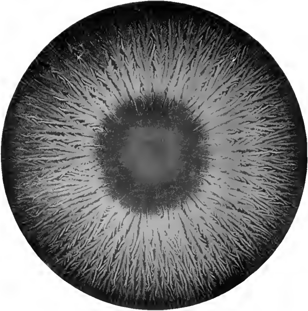


Fig. 4.

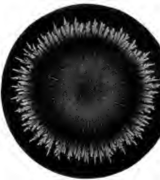


Fig. 5.

Fig. 6.

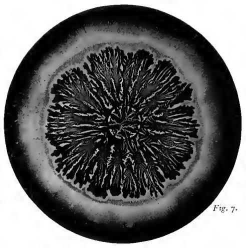


Fig. 7.

Fig. 8.

Fig. 9.

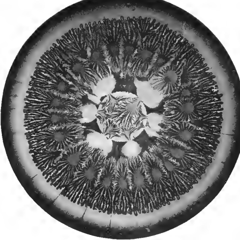


Fig 10.

Fig. 11.